Chapter 1
Introduction

1-1. Purpose and Scope

This manual provides guidance for the selection, design, installation, operation, and maintenance of cathodic protection systems (CPS's) used to supplement paint systems for corrosion control on civil works hydraulic structures. It also discusses possible solutions to some of the problems with CPS's that may be encountered at existing projects.

1-2. Applicability

This manual applies to all USACE Commands having civil works responsibilities.

1-3. References

a. MIL-HDBK-1004/10, Electrical Engineering Cathodic Protection.

b. EM 1110-2-3400, Painting: New Construction and Maintenance.

c. ETL 1110-9-10, Cathodic Protecion Systems Using Ceramic Anodes.

d. CW-09940, Painting; Hydraulic Structures and Appurtenant Works.

e. CW-16643, Cathodic Protection Systems (Impressed Current) for Lock Miter Gates.

f. TN ZMR-3-05, Components of Hydropower Projects Sensitive to Zebra Mussel Infestations.

g. NACE International Standard RP0169-96, Recommended Practice, Control of External Corrosion on Underground or Submerged Metallic Piping Systems.

1-4. Background

a. General. The Corps uses CPS's in combination with protective coatings to mitigate corrosion of hydraulic structures immersed in fresh, brackish, or salt water. Protective coatings are rarely completely effective because, even on application, they contain pinholes, scratches, and connected porosity. As coatings degrade with time, these imperfections, commonly known as holidays, have a profound effect on overall coating integrity because of underfilm corrosion. CPS's, when used in conjunction with protective coatings, have been effective in controlling corrosion. CPS's consist of anodes that pass a protective current to the structure through the electrolyte environment. CPS's can be one of two types, sacrificial anode or impressed current anode. Hydrid CPS's installed on structures can contain both types of anodes to provide protective current.

(1) Sacrificial anodes, such as magnesium or zinc alloy, corrode and wear more readily than the structure to be protected because of their more negative electrochemical potential. Sacrificial anodes do not require an outside power source; rather, they provide their own power and need very little maintenance. They should be replaced whenever the anode material has been consumed, so they should be easily accessed. Sacrificial anodes are generally recommended for use with a well-coated structure with minimum chance of being damaged during its useful life.

(2) Impressed current anodes are made of durable materials that resist electrochemical wear or dissolution. The impressed current is supplied by a power source such as a rectifier. All impressed current CPS's require routine maintenance because they involve a power supply and a greater number of electrical connections than do sacrificial anodes. However, impressed CPS's can be used with bare or poorly coated structures because of the greater current capacity.

b. Locations. Since 1950, USACE has used impressed current CPS's with graphite or high-silicon, chromium-bearing cast iron (HSCBCI) anodes. The first systems were installed on the Mississippi River near Rock Island, IL, on an experimental basis. Since then, CPS's have been used widely. About 22 CPS's were installed and are currently functioning on structures on the Tennessee-Tombigbee Waterway, the Alabama River, and the Black Warrior River in the Mobile District. CPS's have been used successfully on the Intercoastal Waterway on seven sector gates in

the Jacksonville District and on miter gates in the New Orleans District. Impressed current systems have also been installed on three lock gates on the Columbia River in the Northwest. Similarly, impressed current systems using both graphite and HSCBCI anodes were installed on lock gates on the Ohio River during the 1970's. However, ice and debris damages have made most of these systems inoperable. Since the early 1980's, a new type of ceramic-coated composite anode material has been used for various electrochemical processes, particularly in the electrolytic production of chlorine and cathodic protection systems, including off-shore, water tank, and groundbed applications. The mixed metal oxide ceramic-coated anodes consist of a conductive coating of iridium or ruthenium oxide (IrO2 and RuO2, respectively) applied by thermal decomposition onto specially prepared titanium substrates. The coatings are applied by spraying aqueous metallic salts onto the titanium substrates and heating to several hundred degrees Celcius. Multiple layers of coating material may be applied by the process to provide a maximum coating thickness of approximately 0.025 mm (1 mil). This type of CPS has been used at Pike Island and other locations with good results.

c. Inoperable impressed current systems. Most of the inoperable impressed current systems encountered were utilizing graphite anodes that were more than 20 years old. Only a few navigation structures have had systems that utilized sausage string cast iron anodes provided with impact protection. Properly maintained cast iron anode systems that have been in high-impact debris areas have shown good results. Graphite systems in low-impact debris areas have also shown good results.

d. Inoperable sacrificial anode systems. Zinc or magnesium sacrificial anodes provide some benefits, but typically, these anodes only protect small areas such as well-coated structures, and they experience higher consumption rates than anodes normally used in an impressed current system. In order to be beneficial, sacrificial anodes must continue to apply current to the structure. Consequently there must be periodic voltage testing, and the system must be kept optimized by anode replacement to continue its performance in accordance with acceptable criteria.

e. Solutions.

(1) Restoration of systems. Most existing inoperable CPS's at navigation structures can be restored. This approach is less expensive than installing complete new systems, and therefore should be considered first. When graphite anode strings are consumed or destroyed, they can be replaced with impact-protected cast iron anode strings or ceramic-coated wire. In many cases, anode strings can be replaced and systems can be repaired without dewatering a lock.

(2) New or replacement systems. Designers should use Guide Specification CW-16643 with this manual for new CPS installation or for complete system replacement when necessary.

f. Effective techniques. National Association of Corrosion Engineers (NACE) Standard RP0169-96 contains the recommended practice for control of external corrosion on civil works hydraulic structures. It includes criteria for both coatings and cathodic protection and should be used in conjunction with guidance in this manual and with painting design guidance in Engineer Manual EM 1110-2-3400. NACE Standard RP0169-96 should also be used as guidance unless noted otherwise, and designers should become familiar with it.

g. Resistivity policy. Cathodic protection should be provided on all submerged metallic structures. If, after performing a corrosion mitigation survey, an NACE-certified corrosion specialist or a professional engineer deems cathodic protection unnecessary due to a noncorrosive water, a statement to that effect should be prepared and sent to the district project manager as a part of the corrosion plan.